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## Designing for emergent interactions

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# Designing for emergent interactions.

## Strategies for encouraging emergent user behaviour & serendipitous research findings

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**Abstract:** In this paper, we discuss emergent interactions as a design strategy in the context of cultural museum exhibitions, and how we can use these strategies to be more open to serendipitous findings in design research. We propose that emergent narratives can be transferred to the design of interactive exhibitions, and thereby removing the constraints and open use situations for more personalized, and potentially structure-breaking user experiences. Whereas much research in accidental discoveries in design focus on discovery in the design process, we propose the same accidental discoveries might be transferred as design strategies aimed at the end-users themselves making emergent interactions that can inspire serendipitous discoveries in research and design. As such, we ask the research question if we can leverage serendipitous findings from the design process to create the potential for emergent interactions for the user?

**Keywords:** emergent interactions, emergent narratives, design strategies, research through design, cultural exhibitions

## 1. Introduction

In 2017 Nintendo released The Legend of Zelda: Breath of the Wild (BotW) – the most recent game in a long running series of adventure role playing games. The game received much praise for its emphasis on exploration in an open and responsive world, which gives the players a set of relatively simple game mechanics, but which through a robust physical rule set achieves a wide range of gameplay situations that diverge from the games story (Gray, 2017). Furthermore, the game makes little effort to nudge users back into its pre-configured story structure, but rather lets users spend hours exploring mechanics and their possible consequences and has confidence in players to be stewards of their own experience from individual non-scripted choices during exploration.



Figure 1: Stills from *Legend of Zelda: Breath of the Wild* – a user exploring the boundaries of what can be physically manipulated in the game's terrain. Copyright © Nintendo.

BotW, and similar games like *Grand Theft Auto*, *Minecraft*, *The Sims* etc. creates an alternative way of approaching the user experience with an open story world that gives users the power to personalize their experiences through emergent gameplay not scripted (or maybe even conceived) by the designers. While the degree of potential emergence differs, there is a clear pattern among current bestselling games towards giving users a simple set of mechanics to combine in personalised ways (Gray, 2017). Furthermore, a tendency in this wave of digital game design strategies is for the designers themselves to change their mindsets towards how to approach unexpected serendipitous findings from the design process. In the past, if a player did something not planned, or found a different solution to a problem in a game, the game designers would usually label this as a 'bug' to be fixed. Now, this level of experimentation, pushing the boundaries is not only allowed, but actively encouraged, and often being later transformed by the designers from a bug into a feature of the system (Brown, 2016). This tendency in game design can be seen as a way of utilizing emergent behaviours actively; i.e. treating them as happy accidents in the design process. Here we understand emergence as novel and unexpected properties discovered in a system as whole, without them being deducible from the individually designed components of the system (Goldstein 1999). It is in a sense, a design strategy aiming to allow the whole to become greater than the sum of the design's individual parts.

This observed tendency aligns with the rise of personalized technology over the last two decades and new demands raised by users wanting to customize and personalize their cultural experiences. This leads us to ask what we can learn from the utilization of emergent behaviours arising in games? Can we apply this notion of designing not only for, but also through unexpected user behaviour and use the game fields' open story worlds and/or emergent gameplay in other physical contexts to give users a chance to break structure and creatively play with their own narratives? And how does that affect the potential for serendipitous findings through, and with design research and user studies?

In this paper, we approach these questions from the context of cultural exhibition design, such as museums, zoos, and galleries. The landscape of exhibition design is currently undergoing fundamental changes; from static one-way communication, focusing on enlightening visitors, to interactive participatory exhibitions focusing on personalizing meaningful experiences (Drotner et al., 2011; Skot-Hansen, 2008). This 'flux' in the field makes it a relevant context for discussing how to both design for, and design through serendipitous emergent user behaviour, and whether emergent interaction design is a viable design strategy within design research.

## 2. From emergent narratives to interactions

In 1999, Goldstein described emergence as a construct, building on theorists such as Bedau (1997), writing “[...] *arising of novel and coherent structures, patterns and properties during the process of self-organization in complex systems.*” (Goldstein, 1999; p49). Aylett (1999) further described emergent narratives as structures constituted by, or generated from underlying processes of a user experience. In Aylett’s research, she challenges different narrative approaches to understand how far a pre-determined nature of narratives can be relaxed by approaching the behaviour of emergent narratives as bottom up experiences that happen through the interactions between essential but simple components in virtual environments (Aylett, 1999).

Jenkins (2004) described emergent narratives in connection with understanding game design as a narrative architecture. He argues that emergent narratives are not pre-structured, but taking shape through game play by having game spaces that are designed to be rich with narrative potential. Juul (2005) describes emergent narratives along the lines of Jenkins, but in a game design setting. Juul simplifies the understanding of emergent narratives by describing the term as being equal to a player’s experience of a game, or rather the stories that a player has created while playing a game. Dorman (2008) further explores the design consequences in addressing the complexity of designing for behaviour that “[...] *is notoriously difficult to predict and can uncomfortably feel like magic*” (Dormans, 2008; p1).

Swartjes (2010) also notes this complexity of emergent interactive stories where emergence can be seen both as “[...] *the paradox between free-form interactivity from a first-person perspective and narrative structure, and as a design approach.*” (2010; p69). Swartjes states that a narrative is emergent if there is no pre-determined plot, and when the narrative is the result of how the user accumulates past actions and events as coherent and meaningful. Emergent narratives might exist alongside a traditional plot structure, if a meaningful experience is possible outside the plot. Walsh (2011) frames this accumulative structure of emergence as a more general characteristic of interactive media – not just a genre of game design. Walsh’s focus is not just on emergent narrative, but also its relation to emergent behaviour, arguing that story arises from behaviour, and behaviour is enabled by forming narrative meaning.

### 2.1 How to understand unexpected interactions as they emerge

Emergent interactions happen when a user takes unexpected or unintended action in a context using the mechanics and agency given to them, building upon a pre-defined structure. Thus, emergent interactions are users’ creative interpretation and negotiated meaning of an interactive context, whether it is going with or against the intended use. We can view this through the optic of Hall’s (1980) encoding and decoding positions, for how a user negotiates the decoded meaning behind designed structures. Hall (1980) described three hypothetical positions for decoding a respective encoding; *preferred*, *negotiated* and *oppositional readings*. *Preferred reading* being full and straight decoding of a message, “*the perfectly transparent communication*” (Hall, 1980; p125). *Negotiated reading* is when a user understands how a message should be decoded, but deliberately negotiates the meaning-making process, which Hall describes as “a mixture of adaptive and oppositional elements” (1980; p127). Lastly *oppositional readings* being the diametrical opposite decode of *preferred readings*, where users know and understand the preferred reading of a contexts but choose to “*decode the message in a globally contrary way*” (Hall, 1980; p127).

Hall's position enables us to categorise emergent interactions as what happens when users either intentionally or unintentionally negotiate or (intentionally) oppose their reading of a context. This means that an interaction becomes more than mere functionality for one specific decoding, and more a potential variable for the design to carefully consider and observe how it might reveal emergent behaviours. As such, the emergent interaction is not a function of the system itself, but a combination of negotiated or opposed interactions with the system in highly contextually dependent situations. If design researchers are willing to loosen the structure of designs and open the design process so as not to view users' creative interpretation and negotiation as 'bugs' to fix, but rather address emergent behaviour as a possible feature of a design. It is from this position we create a space for design researchers to observe unintended and emergent behaviour, interactions and uses that can inspire serendipitous findings for further design iterations.

### 3. Emergent Interactions: As Principles

In this section, we approach the idea of loosening the structure to inspire serendipitous findings, by looking at how we can design for emergent interactions. Based on Aylett and Swartjes definitions of emergent narratives, we point to four main characteristics of designing for emergent interaction. These four characteristics are; *User-mindset*, *Agency*, *Storification* and *Narrative Closure*.

Table 1. Principles of emergent interactions

Principles	Description
<b>User-mindset</b>	For an emergent gameplay to happen and an <i>emergent narrative to be created</i> , users must be willing to explore the story world that they are presented with. How can we through our design (process) affect users' mind-set to be curious and explore the given context?
<b>Agency</b>	Agency refers to users' ability to act and interact in an environment. To evoke users' agency, they have to be able to move freely in a story world and have a social presence in the environment.
<b>Storification</b>	The subjective assimilation of events unfolded dependent on users' actions within an environment. For users to create their own storyline or narrative they must be active explorers and be given the agency to interact and act. Thus shaping their own path and thereby narrating their own subjective meaning.
<b>Narrative Closure</b>	For a narrative to be desirable it must have an ending. To achieve narrative closure in an emergent narrative, it is necessary to have a debrief at the end of the experience or to create the opportunity for a discussion.

It is evident that the four principles focus on users' ability to freely engage in an experience and support them in their creation of personalized narratives, despite the necessary existence of an underlying structure. Even though emergent narratives are defined for virtual environments, the opportunity for deploying these principles into a physical context does, in theory, seem possible. None of these four principles necessitate to be strictly constrained to virtual spaces or a game context. Emergent narratives demand a free-form interactivity in a non-linear and high-agency environment (Swartjes, 2010) which in principle can be a challenge when considered in a physical context such as exhibitions. They are, despite their increasing implementation of interactive experiences, still institutions where the main purpose is to enlighten citizens about nature and

cultural heritage. This means that most exhibitions focus on creating linear storylines or near-curriculum structures to ensure the correct communication of history, even though exhibitions are referred to as free-choice learning spaces (Falk & Dierking, 2013), thus creating a paradox where the structure creates limited options for users' free-choice experiences.

Considering this, the proposal for applying emergent interaction in physical exhibition contexts is a proposal to approach the design research process of such contexts through the lens of using emergent behaviour as active design inspiration; not just to allow users to experiment, but to actively encourage them to make *negotiated* and *oppositional* readings and form their own meaningful experiences.

## 4. Strategies of Emergent Interactions

Our point of departure is to examine whether the design of exhibitions can utilize the potential of users' emergent behaviours as seen in digital open world games. We argue that this is not just a question of providing more choices, but rather to let the experience be causally dependent on an established structure where the emergent narratives evolve alongside, or even in spite of the existence of said structure. We argue that we design a space for design research and user studies that allows for serendipitous findings by removing constraints and structure through the idea of open story worlds and emergent interactions that allow users to explore storylines and exhibition installations as they see fit, rather than how the museum designers or researchers have pre-structured. From studying a series of exemplary cases in which the authors have experimented with emerging interactions in museums, we suggest four strategies for designing both for- and through emergent interactions; *by design*, *by re-design*, *by creative play* and *by hacking*.

Table 2. Table of the four strategies of Emergent Interactions divided under Design Driven and User Driven

Strategy	Description
<b>Design Driven</b>	<i>By design</i> and <i>by re-design</i> we define as being <i>design-driven</i> strategies of emergent interactions, focused on creating potential for emergent interactions based on active intervention from the designers.
by Design	A strategy for designing museum exhibitions that encourage emergent behaviour by applying the four principles of emergent interactions to the design process.
by Re-design	A strategy for redesigning an existing exhibit inspired by the emergent discoveries from the user driven strategies; <i>by creative play</i> and <i>by hacking</i> .
<b>User Driven</b>	The User Driven strategies are strategies focused on analysing and understanding emergent user behaviour in experiences, and based on this design research, assess whether or not to promote the emerging interactions into features through either <i>by Design</i> or <i>by Re-design</i> .
by Creative Play	<i>Creative play</i> represents the emergent interactions that happen by accident while users interact with the context they are in, negotiating their understanding of their options.
by Hacking	<i>Hacking</i> is when the users understand the rules but decide to do the opposite, or at least to challenge the mechanics of their experience.

The next section provides empirical exemplary cases for each strategy, mainly derived from research-through- and research-on-design practices (Koskinen et al., 2011) in which the authors have been involved.

## 4.1: by Design

We define the *by design* strategy as the most fundamental, but potentially also the most challenging for enabling and encouraging emerging interactions. This strategy is applied when the purpose of a design endeavour is to make exploration the *preferred reading* for users – to find their own meaningful experiences, not because of structure but despite structure. This is a paradox, having already defined emerging interactions as *negotiated* and *opposing* readings, and thus not something we can plan for as encoded prior to users' exploration. Therefore, with this strategy the four principles of emergent interactions become essential - both as general design principles and as design research principles to translate serendipitous findings from the research process into open-ended features in the final design outcome.

We have applied *by design* when designing a temporary exhibition at a Danish maritime museum 'Limfjordsmuseet' (see figure 2), using the four principles as part of the design guideline. The purpose of applying *by design* to this exhibition, was to challenge the museum users to have a more exploratory behaviour, and challenge the cultural convention of what it means to visit an exhibition. The four principles were embedded in the design process of the exhibition so as to design a more open story world around the history of the significance of eels for people living by and off the fjord through time, and thus create a space that inspired creative play and exploration of the exhibition's potentials and boundaries.

*User-mindset* became the most challenging principle. What we wanted users to do in the exhibition was far from their natural behaviour in a museum space. In an attempt to affect *user-mindset* we told users how we wanted them to act and interact; be curious, explore, touch and interact. We designed for *agency* by removing all glass displays and placing all artefacts openly in the exhibition. Some artefacts were placed in ways that forced users to interact with them. Hidden around or on these artefacts were small notes with "*did you know...*" facts, bottles with messages, sensor activated audio stories and personal letters from fishermen to their loved ones. This, together with the traditional explanatory posters gave the users option of choice of which stories and narratives they wanted to read and follow, creating their own *storification*. And lastly, we applied the principle of *narrative closure* by providing a dialogue question at the end of the exhibition, where users could reflect on what they had learned.





Figure 2: Stills from the temporary exhibition 'The amazing eel' at 'Limfjordsmuseet'.

As such, we designed an exhibition that loosened the structure of the communication design with multiple story layers. The exhibition provided users with a higher degree of *agency* and potential for interaction, by allowing them to physically interact with all artefacts. This provided the potential for emergent behaviour and exploration, but *user-mindset* was a challenge. Being curious and wanting to explore what we find interesting is a natural state for human beings but, our cultural conventions when it comes to our behaviour in museum spaces, created a challenge in getting people to let go and freely interact and challenge the museum exhibition. Wanting emergence as a preferred behaviour was thus inhibited by conventions of much more strict structure than the experimental and explorative space offered. This was responded to by having the custodian introduce and explain the “rules” of the exhibition to users.

Again, this shows the paradox of actively planning to design for emergent behaviour by ending up needing to design a service introduction (a structure) to enable exploration of independent behaviours through exploring many different and unplanned interactions. Thus, an important lesson learned is, that the *by design* strategy will almost certainly require the design researcher to continuously adapt and adjust the structures iteratively, in order to accommodate users forming emerging behaviours *despite their culturally* dependent expectations to the structure of a given design space. This is what we will define as *re-design* strategy for emergent interactions.

## 4.2: by Re-design

We define *by re-design* as potential adjustment of an existing design, based on observed emerging behaviour amongst users, and allowing users to further explore the boundaries of an exhibition. This strategy can be fuelled by insights of user studies that may be derived from the user-driven strategies; *by creative play* and *by hacking*. Which means that a redesign is inspired by users' *negotiated* or *oppositional readings* (Hall, 1980) of an existing context.

In our experiments we worked with the aqua zoo 'North Sea Oceanarium' on a mobile augmented reality (AR) application design for smartphones (see Vistisen, Østergaard & Krishnasamy, 2017). The app was designed to be used throughout the entire exhibition, encouraging users to find seven

locations to film short video clips of their families with live added AR animations of various aquatic elements (see figure 3). After filming in all locations, the app creates a small 1-minute movie with special effects of the visit. As such, the preferred reading of the design was to give a certain degree of free *agency* to users (i.e. the order of the locations was not strict) and provide a story-driven structure with a clear *narrative closure* and ending with the final AR movie.

However, upon the first prototype implementations, and well into the actual implementation, the design team discovered that many users seemed to follow several different diverging paths for creating the seven film clips. While some users followed the structure (find location, film, find new location etc.), just as many users chose to play with effects at various other locations throughout the aqua zoo. Here, users sought to explore how they could manipulate the AR effects in new ways and, to our surprise, how to actively incorporate this in reflecting upon the real-life behaviour of the animated flora and fauna.



Figure 3: Images of the augmented reality app, with users playing with the interactions (left), and a mockup of the new stationary app re-design (right).

As such, we observed how *user-mindset* was much more curiosity driven than anticipated, and driven towards exploring how far they could push the constraints; thus, showing a much higher degree of *agency* than anticipated. Most fundamentally though, the strict structure of the seven locations, and their pre-defined story and *narrative closure* was clearly being negotiated into individual, but just as meaningful, emerging interactions with app and the zoo context.

Initially a *re-design* iteration was made, attempting to guide the user into the structured *mindset* of following the seven locations around. This was done by sign posts, advertising, zoo personnel interactions, and social media posts. While this attempt to enforce the strict structure had some impact on users' behaviour, it did not suppress the emerging uses of the app. Rather, it made more guests aware of the app, and thus sparked an even larger wave of variations in use. This finally led to the most recent re-design, in which the app has been changed from being focused on users' own smartphones, to be a stationary large screen version, mounted as a 'film playground' in the zoo. Here, *agency* is adjusted to be more constrained (stationary vs. mobile), but at the same time increased in terms of interplay between user and app, since the 'goal' of the app is now much less structured, and open to individual interpretations. The *storification*, of this *re-design*, is not



emphasised towards completing all seven film clips, but rather for families to explore what creative ways they can interpret, adjust, and manipulate the mechanics so as to create meaningful experiences. These accumulated *negotiated* readings of the stationary app experience encourage emerging interactions observed through the design research process, and re-assigned these unexpected behaviours into use for the re-design.

### 4.3: by Creative Play

*By creative play* is the accidental occurrence of emergent interactions that can happen when users play with or in an exhibition space. Creative play is emergent interactions that happen by chance while users interact with the context that they are in, *negotiating* (Hall, 1980) their reading and playing with the *agency* given to them. This strategy is *user driven* and, therefore, an emergent behaviour we can observe or design for through the *design driven* strategies.

An example of creative play can be observed at LEGO's new museum LEGO HOUSE, where they have built a waterfall entirely of LEGO components (see figure 4). Around the waterfall are large pits of LEGO bricks for the users to build, play with and exhibit on plateaus placed around the sculptures. The waterfall is glued together, which indicates that LEGO does not want people to reshape the waterfall. But with LEGO being a building solution, users have started to exhibit their small creations on the waterfall instead of on the plateaus. Thus, if it is not behind glass users might read it as not being off-limits. Consequently, users play with everything they have at hand and become part of evolving the waterfall through creative play. This might or might not have been intended, but as users might perceive their actions as a negotiated reading, with the waterfall being glued together, their actions become *creative play*.



Figure 4: The image on the left shows LEGO HOUSE's waterfall installation. The two images on the right show some of the small additions added to the waterfall by users through their creative play.

Users visiting LEGO HOUSE are in a *mindset* of playing and building when visiting the home of the LEGO brick. They are given *agency* with LEGO bricks being everywhere for users to play with, build and

display. Thus, users create their own LEGO creations and they create small narratives for each new creation to shape their *storification*. LEGO HOUSE provides a *narrative closure* by providing photo-stands on all levels, where users can take photos of their creations in a scenario connected to the level they are on. The photos are uploaded to a personal account for users to download when they finish their visit. This emergent behaviour of creative play might promote the design team to redesign their waterfall and encourage users negotiated reading of the waterfall, or they might use it to stop the 'bug'. Either way, being aware of this behaviour in the design process might lead the design researcher to unexpected findings.

#### 4.4: by Hacking

The final design strategy comes close to the original game design strategy of using 'bugs' to let novel and unexpected use potentials emerge. This strategy is based on emergent interactions arising when a user challenges the structure of an exhibition to create alternative interactions - making an intended *oppositional reading* that can result in, for the designer, an unexpected 'hack'. Here users understand the structure and its *preferred* readings, but decide to do the opposite or challenge the mechanics.

One example of such oppositional readings can be found in another design case from the aqua zoo 'North Sea Oceanarium' – a didactic learning design around the oxygen capacity for different animals. Here, users are asked to hold their breath while pushing a big button that counts time. Meanwhile an oxygen bar shows how a user compares with different animals (e.g. seals, dolphins etc.), and provides the user with an AR effect projected on their face each time they surpass one of the given animals (see figure 5).

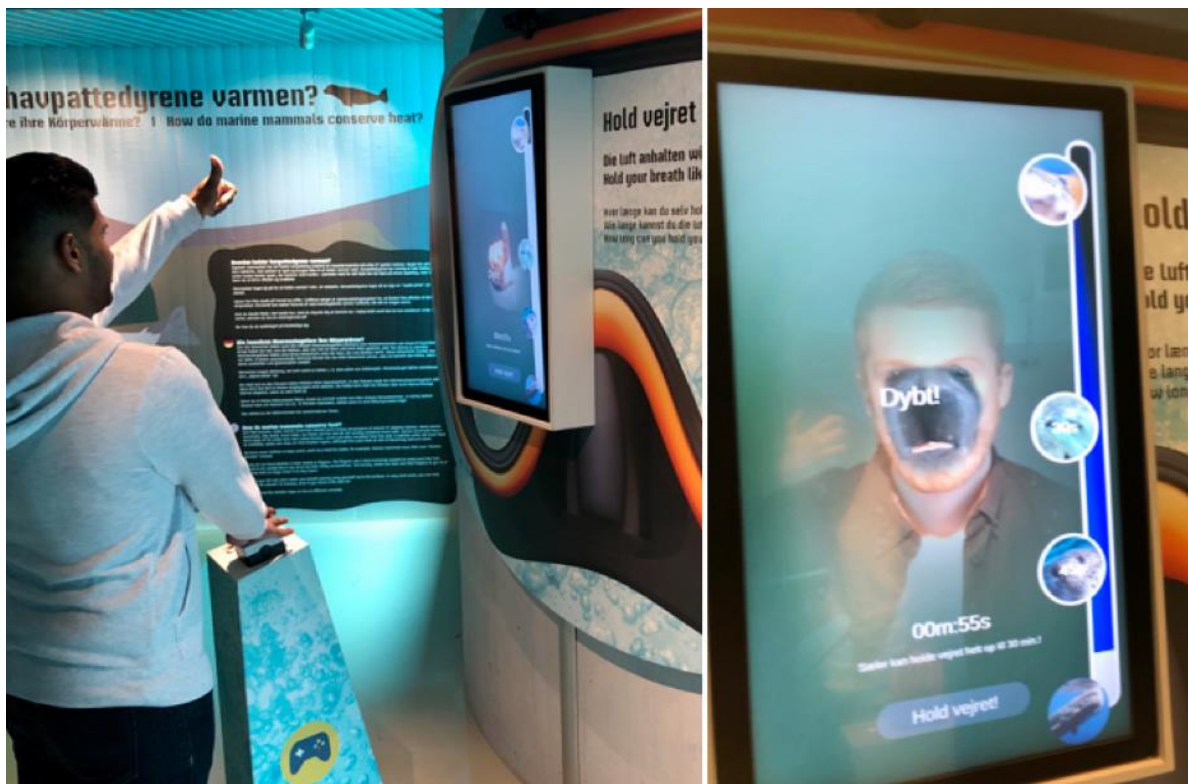


Figure 5: The 'Hold your breath like aquatic animals' installation, where users receive augmented reality effects as progress rewards, with users to the left just pretending to hold his breath for 55 seconds to see the final effects.

During user testing many users adhered to this rather strict structure and interaction, competing to see who could compare with the best performing animals. However, many users were also greatly



challenged when having to compete with e.g. a seal's ability to hold its breath underwater, and it was practically impossible to hold the breath to reach the level of the dolphins and whales - even though the scale was adjusted from 1:1. Instead of retrying to beat their time, we observed an emerging behaviour where users immediately understood the structure of the product (hold your breath, and hold the button down to play), but also immediately opposed the structure. Here, users 'acted' as if they held their breath by breathing through their noses, while still blowing up their chins to act as if they followed the structure while still holding down the button, and achieved the different AR rewards. Thus, users opposed the structure, and formulated their own goal (to see all the information the product could offer) and interacted accordingly. Interestingly, the aspect of 'acting' as if they followed the structured also reveals how the hacking strategy often emerges from a previous creative play strategy. This situation might earlier have promoted the design team to do an iteration of the product, changing the product so most users would be able to hold their breath for the entire session. But due to a continuously observed emerging behaviour, this *re-design* was abandoned to let users benefit from their 'hack', and feel more creative and empowered while still achieving the same *narrative closure* as the *preferred* reading.

Oppositional interactions can emerge not only from the end-users, but also from an organisation 'hacking' a product to e.g. better serve user needs. This type of emergent interaction happened during the first months of testing a new 100m<sup>2</sup> interactive screen installation at the North Sea Oceanarium. The screen was made to enable visitors to experience whales in full size and use mounted tablets to play through the food chain in the ocean. However, the staff realised that at some points during the day, visitors were also inclined towards not playing, and instead requested deeper narratives to form a clearer *storification*. By an unexpected tweaking of the game system, staff and designers saw they could load other content on top of the large 3D game environment; i.e. PowerPoint slides, video footage, and interactive infographics (see figure 6).



Figure 6: Pictures of the employees hacking the 100 m<sup>2</sup> LED screen software to use for presentations and infographics instead of didactic games as seen on upper left image.

This emergent interaction happened by exploring the *agency* provided by the back-end system; not as a direct instruction or through a clear structure, but rather as an oppositional reading from staff with a *mindset* aimed at exploring the systems mechanic to continuously adapt to user behaviour. The common factor, for both the end-user and staff variants of by hacking is the clear *user-mindset* of acknowledging the preferred structure, but then actively opposing it through the *agency* of exploring what other possible interactions and narratives might be possible with the emergence of unexpected interactions.

## 5. Discussion

As exemplified through the strategies, designing for emergent interactions, be it by design or by redesign, strives to stimulate the *user-mindset* to creative play or *hacking* by giving users *agency* in their experiences. The strategies are inevitably interconnected but provide us with an opportunity to perceive emergent behaviour and interaction from both a design and user perspective. Thus, using the four principles of emergent interactions across the strategies provides us with a design research framework for design or analytical acknowledgement, and iterations based on unexpected emergent behaviours. Consequently, arguing that both strategies and principles can be effective tools in research-through-design, where the optic of emergent interactions supports processes more open to serendipitous findings, where the unexpected is not just considered as ‘bugs’ or anomalies to be corrected, but possible features to appreciate, and maybe integrate to broaden exploratory *user-mindsets*, given users' *agency* to form their own *storifications* and finally their own *narrative closure*. While Hall's (1980) encoding/decoding positions are not meant for the context of design, but for communication, we argue that the three positions provide a valuable language for design researchers to articulate what happens when users negotiate and oppose the structures presented in a design with unexpected results. This articulation is the first step towards transferring the emergent narrative design from the game industry to physical contexts such as exhibitions, giving designers an optic through which to understand why experimentation, exploration, and independent user interpretations should not just be allowed, but maybe even encouraged.

While our presented cases have shown examples where unexpected behaviour became either encouraged or directed into a re-design, we do not suggest that all ‘bugs’ are equal and can be serendipitous findings that can improve a design. Traditional iterations based on e.g. usability are still, and should be important considerations in the design process. However, we do argue for emergence to keep an open mind to the possibilities of loosening structure and allowing users the agency to challenge the designs and ideas through creative play and hacking to provide us with new insights. We are not, in this paper, arguing that emergent interactions provide more or less enjoyable experiences for users, but rather view unintended user behaviours as serendipitous opportunities for design rather than bugs that needs to be fixed.

Another point of discussion is the context in which we have applied the strategies. A museum space is a context in which research is done within different traditions and a context open for experimentation in the light of challenges from the experience economy and users' demands for experiences (Skot-Hansen, 2008). This makes museums open to challenging their exhibition practices. Therefore, they provide an interesting context in which to employ research through and with design, and design process focused on emergent interactions. This does not seclude the strategies and principles to a physical space of exhibitions, as they can potentially also be applied to other physical contexts.

## 6. Conclusion

Inspired by game design theory, we have derived four essential characteristics for emergent interactions from literature on emergent narratives and emergent gameplay, which we argue can be applied to a physical context such as a museum. With these principles we have a guideline for designing both for and with emergent interaction, and for identifying emergent user behaviour throughout a design process. Taking the principles from theory into studying a series of exemplary cases in which the authors have experimented with creating emerging interactions, four strategies have derived; *by design*, *by re-design*, *by creative play* and *by hacking*.

These strategies provide an insight into how we can both design for more emergent interaction in physical contexts (*by design* and *by redesign*) and be aware of emergent behaviour throughout our design processes (*by creative play* and *by hacking*). We argue that if we as design researchers are willing to loosen the structure of our designs and design process to give the user more agency, we create a space for users to explore and challenge boundaries of a context's mechanics. Thus, loosening structure provides design researchers with a space for observing unintentional and serendipitous behaviour, interactions and uses that can inspire further research and redesigns. And if we acknowledge these findings from the design process as potential enablers of emergent behaviour for the end-user, and not simply as 'bugs' and 'anomalies' to be avoided or 'patched', there is a potential for accidentally discover new insights into a design, uses or behavioural enablers. To this end, serendipity in design research might be supported through encouraging emergent interactions to show how the designed whole can become larger than the sum of its parts.

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